LLNL-TR-700439

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Opticondistor by Opcondys, Inc.: A Technical Overview

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August 15, 2016

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Opticondistor by Opcondys, Inc.: A Technical Overview

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The opticondistor (optical transconductance varistor) is a revolutionary new technology that allows for fast switching at extremely high voltages. The technology has been licensed from Lawrence Livermore National Laboratory to Opcondys, Inc. to develop into consumer and industrial products. Compared to existing power semiconductors, such as MOSFET (metal-oxide-semiconductor field-effect transistor) and IGBT (insulated-gate bipolar transistor) units, the opticondistor will provide fast switches at previously unattainable voltages, exceeding 20 kV in a single device.

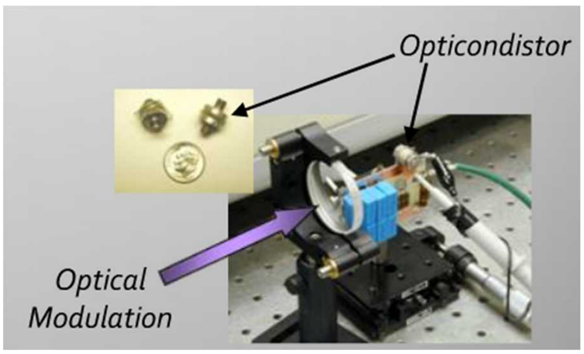

Figure 1: Current *beta* prototype of opticondistor system. The inset shows SiC-containing opticondistor component next to a dime for scale.

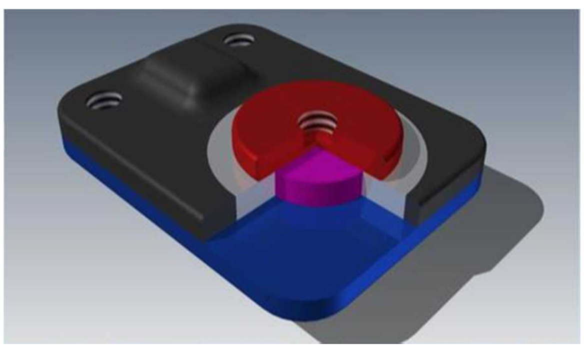

Figure 2: Illustration of the next-generation opticondistor device. The raised gray feature is the light source and the blue region represents the SiC material.

The device is constructed using silicon carbide (SiC) wafers and LEDs. In its ground state, SiC is an insulator. However, when excited by relatively low energy light, such as that supplied by a light source, the material becomes an excellent conductor due to the process known as photoexcitation. The light source emits energetic photons, which are then absorbed by SiC's valence electrons. These higher-energy electrons are then promoted to higher energy levels. In the case of SiC, photoexcitation causes excitation of the valence electrons to the conduction band, rendering the material electrically conductive. When the photon source is turned off, the excited electrons decay back to the valence band on a nanosecond time scale.

The construction and properties of this device offer numerous advantages over existing power semiconductor products.

- Multiple opticondistor units can be stacked together in series to create a single tower that can operate with very high voltages.
- The capabilities already demonstrated in early tests outpace the physical capabilities of competing technologies such as MOSFETs.
- The conducting properties of the SiC material can easily be modulated by increasing or decreasing the intensity of the light source. Additionally, the control is electrically isolated from the device, unlike in current devices where there is no isolation. This electrical isolation allows for cascading systems.
- Because it is made of SiC, the opticondistor can operate at temperatures over 200 °C, much higher than silicon based devices.

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- The opticondistor's fast transition time from off to on and on to off reduces transition energy losses by half. This makes the opticondistor a more energy efficient device than existing semiconductor devices.

Figure 3: A typical industrial induction motor speed control unit and its proposed replacement using opticondistors.

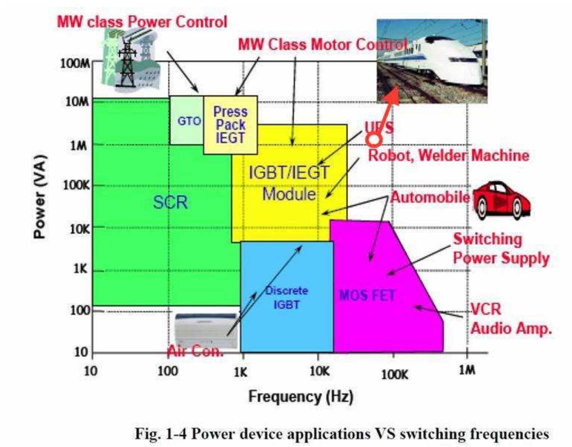

Figure 4: Chart of current power semiconductor devices. Red circle shows opticondistor proof-of-concept test, red arrow show projected capabilities after further development.

- Higher voltage processing means more compact size. Using the opticondistor's stacking ability, the unit pictured in Figure 3 could be reduced in size to a single tower that is smaller, more energy efficient, and easier to manufacture and engineer than existing units.
- As a bulk conduction device without a semiconductor junction, the opticondistor can conduct current in either direction. This bi-directionality provides the ability to reduce the number of switches in equipment by half.

Opcondys' unique device will allow customers to achieve greater performance in high-voltage switching while decreasing energy consumption and unit size and complexity. Preliminary testing shows that a single opticondistor device can achieve switching at more than 10 kV, 75 kHz, and 50% duty cycle, which easily surpasses the capabilities of currently marketed IGBTs and MOSFETs. Additional development will further expand the capabilities of this device, but it has already proven to be a more powerful alternative to current power semiconductors.

There are a wide variety of manufacturers who offer IGBTs, MOSFETs, power MOSFETs, and other devices that occupy the same market segment as the opticondistor. However, these devices have physical limits that are fall short of the currently demonstrated limits of the opticondistor. Thus, once introduced to the market, the opticondistor will be the most capable power semiconductor available.

We expect that this device will be well-received by the high-voltage market. As Figure 4 shows, though there are many other types of power semiconductors, none have the capability of the opticondistor. Industries where we expect to make an impact include renewable energy (power optimizers), energy transmission (HVDC), bioelectrics (electroporation and proton beam therapy), manufacturing (industrial motor control), and electric vehicles (AC-DC converters). In the low-voltage market, the opticondistor will compete alongside traditional power semiconductors, offering smaller size, better energy efficiency, high-temperature operation, and less complex design.

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